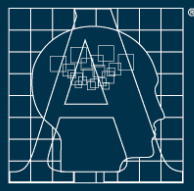

Development of Human Performance Measures for Analyzing Design Issues in Submarine Tactical Control Systems

Cullen Jackson

UHSI Symposium
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- Project Team
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Topical Relevance

- VADM Paul E. Sullivan, Commander, NAVSEA (then Deputy Commander for Ship Design Integration & Engineering) discusses the benefits of using COTS technology in submarine combat systems and the need for flexibility to maintain readiness.

> "The bulk of our combat systems change frequently….the hardware, the software, and the middleware are changing, so your contract has to be designed so that you can keep up with that….It's a much more dynamic situation now. Today, technology refreshment is a part of your program; you have to be agile enough to make sure that you keep up with the technology."
>
> -- *Program Manager, 2001*

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The Problem

- U.S. Navy needs tools to rigorously evaluate the impact of new human-machine interface designs for Combat Control Systems on human performance
  - Critical for maintaining and improving warfighter efficacy when designing and refining system interfaces and user interactions
- This includes knowledge of how best to redesign the combat system interfaces for the individual operator, team, and integrated team with respect to mission performance
- What is needed:
  - Understanding of operator performance data from multiple, heterogeneous sources
  - Understanding of operator and team mission tasks
  - Knowledge of UI “best practices” to enable system redesign

Our Solution

Data Integration for Validation of Effectiveness of Systems (DIVES)

- Competency-based human-system performance evaluation
- Framework for evaluating system impacts on warfighter performance
  - Observer-based measurement
  - System-based measurement
  - Analyses for redesign of system and team processes
- In Phase I, we concentrated on:
  - Observer-based measurement
    - Created a prototype observer-based measurement tool (**SPOTLITE TCS**)
  - Analysis support for redesign recommendations
    - Created storyboards describing how DIVES will support the integration and analysis of performance data

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Evolving the Solution: Three Parts

- Developing competencies, performance indicators, and performance measures
  - COMPASS Process
- Developing an observer-based tool for the collection of performance measures
  - SPOTLITE Tool
- Modifying usability data collection and analysis tool for performance measurement
  - UPDATE System

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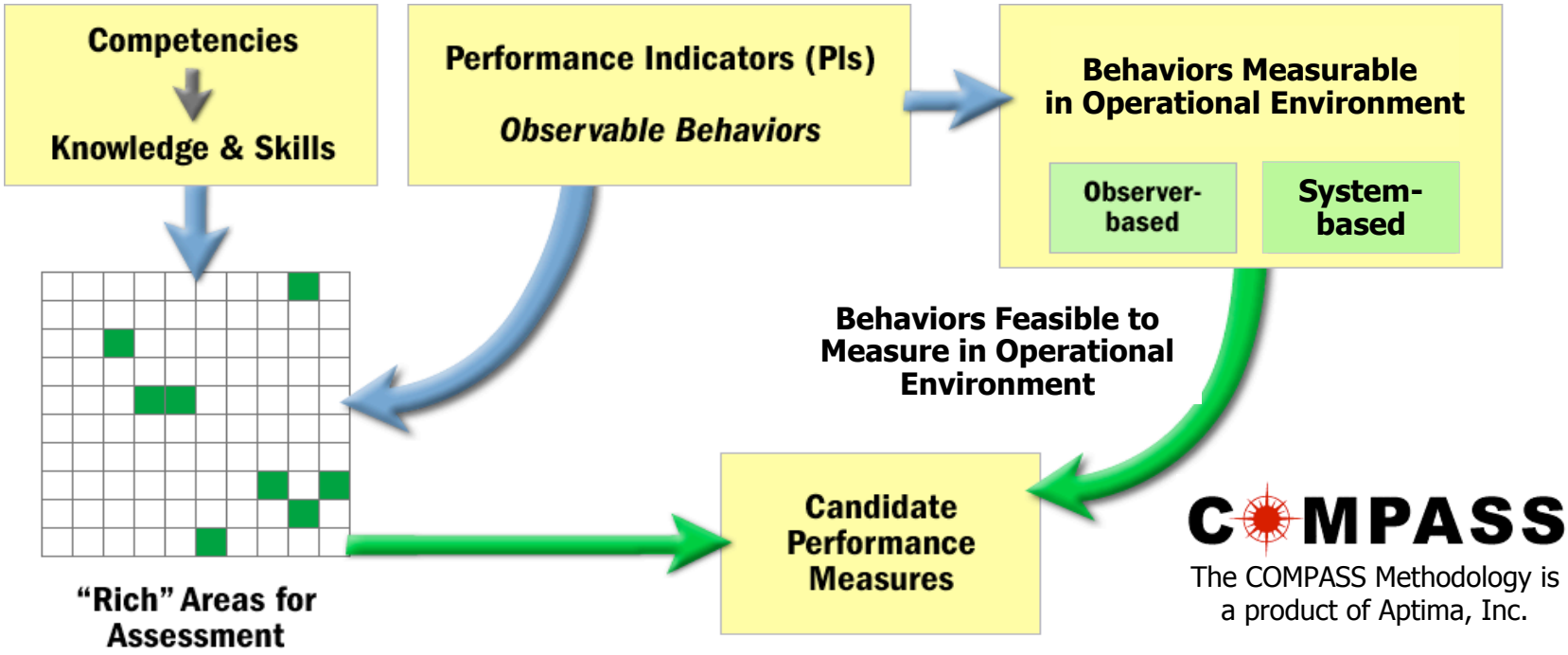
COmpetency-based Measures for Performance ASsessment Systems (COMPASS)



- ***Competency-based*** performance measures
- Leverages ***performance measurement theory*** in combination with ***subject matter expert input***
- Assesses ***team*** and ***individual*** performance

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Performance Indicators

- Performance indicators (PIs) provide information on what warfighter behaviors constitute good and bad performance
- In the context of human-system performance evaluation, an indication of poor performance may highlight a flaw in the warfighters interactions with the system and the need for human-system redesign
  - System display or interaction
  - Operator training
  - Team dynamics

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Sample PIs for Fire Control

- Deals appropriately with unreliable contact information
  - Design Implication: Reliability or uncertainty of contact information is not discernable through system displays or tools
- Deactivates appropriate sensors/trackers
  - Design Implication: System does not provide information on active sensors and/or does not provide ability to activate/deactivate sensors/trackers
- Analyzes target motion based on the types of sensors deployed
  - Design Implication: The user cannot access information on the sensors/trackers being used on the current contact or the information is difficult to interpret
- Performs contact evaluation in a timely manner (5 mins/contact)
  - Design Implication: The menu structure is too dense and does not facilitate rapid interaction with the system

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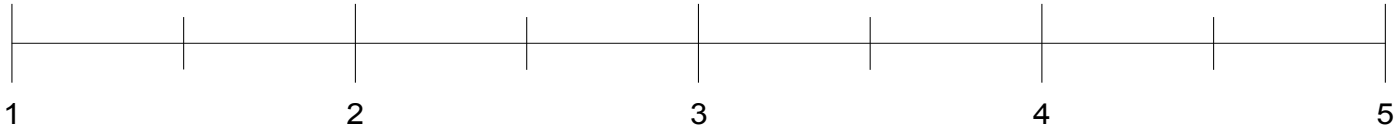
Sample Performance Measures

1. Does the Fire Control Technician use algorithm solutions to refine their own solutions?

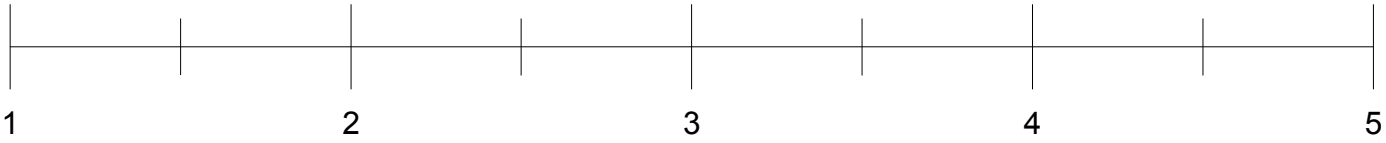
☐ Yes
☐ No

1. Does the Fire Control Technician choose the appropriate sensors/trackers for the contact of interest?



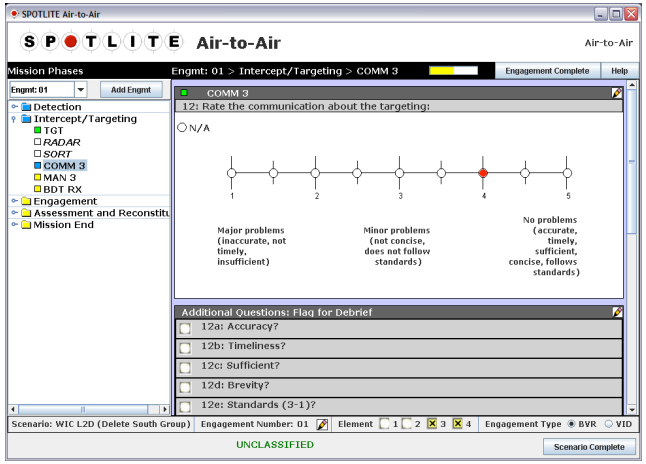
1	2	3	4	5
Does not choose appropriate sensors/trackers		Chooses an adequate set of sensors/trackers		Chooses an optimal set of sensors/trackers

1. Does the Fire Control Technician evaluate contacts and refine solutions based on contact priority, e.g., closest point of approach (CPA)?



1	2	3	4	5
Does not account for contact priority		Adequately accounts for contact priority		Always accounts for contact priority

Scenario-Based Performance Observation Tool for Learning in Team Environments (SPOTLITE)



- Allows ***quick*** and ***easy*** rating of performance in ***real-time***
- Extensively evaluated to ensure ***usability***
- Review performance data in debrief sessions
- Runs on a **hand-held Tablet PC**
- Applied to: Air-to-Air, Dynamic Targeting Cell

SPOTLITE is a product of Aptima, Inc.

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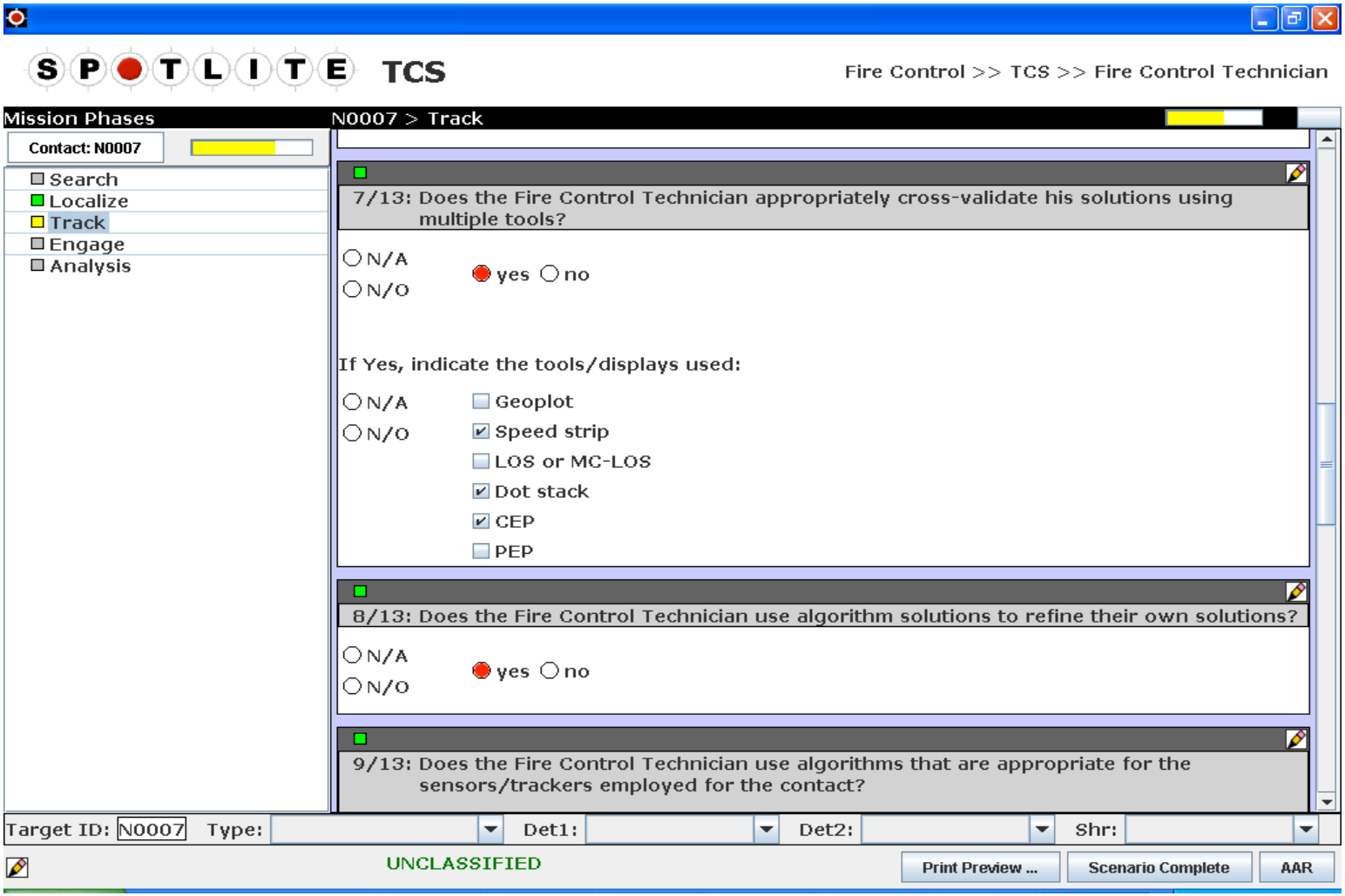
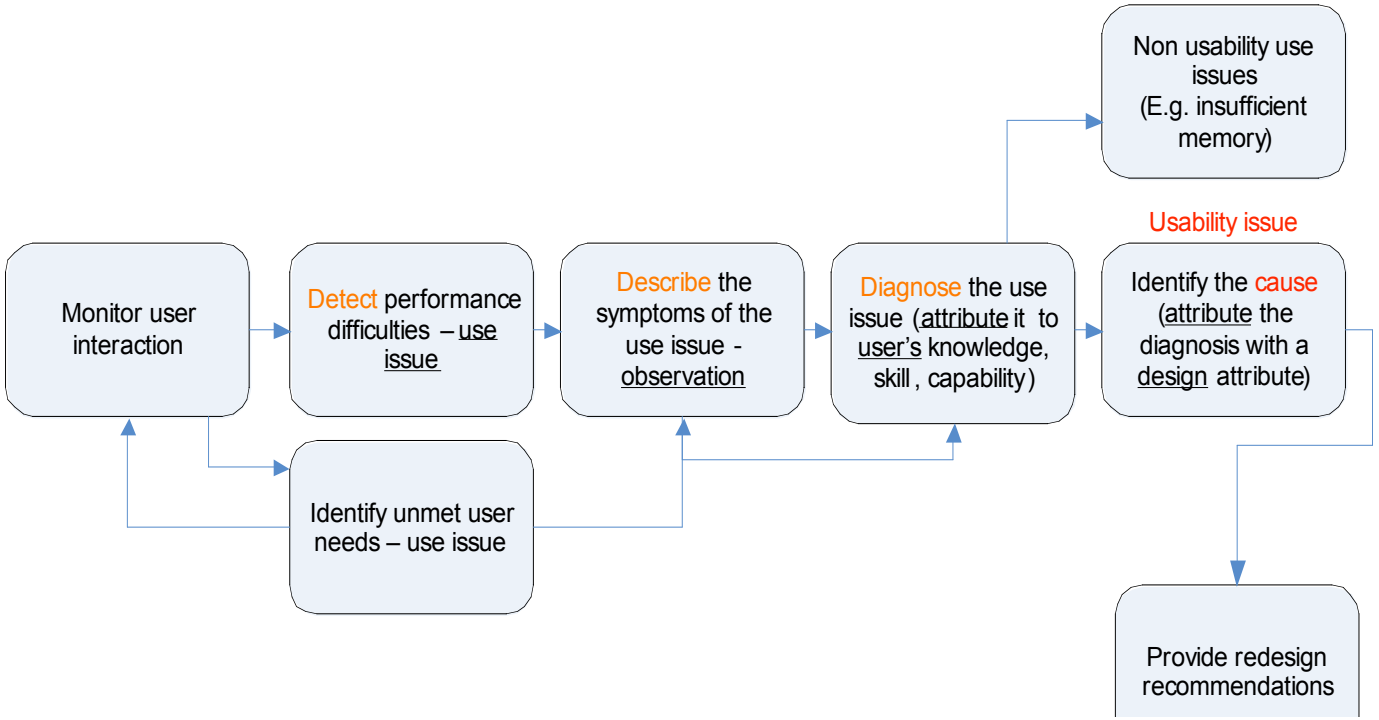
SPOTLITE TCS



Usability Problem Data Analysis Technology (UPDATE)

Objective: Improve effectiveness and traceability of usability data to design problems and back to user behaviors via:

(1) Systematic generation of design change recommendations
(2) Model-based diagnosis of problems



DIVES: Performance Review

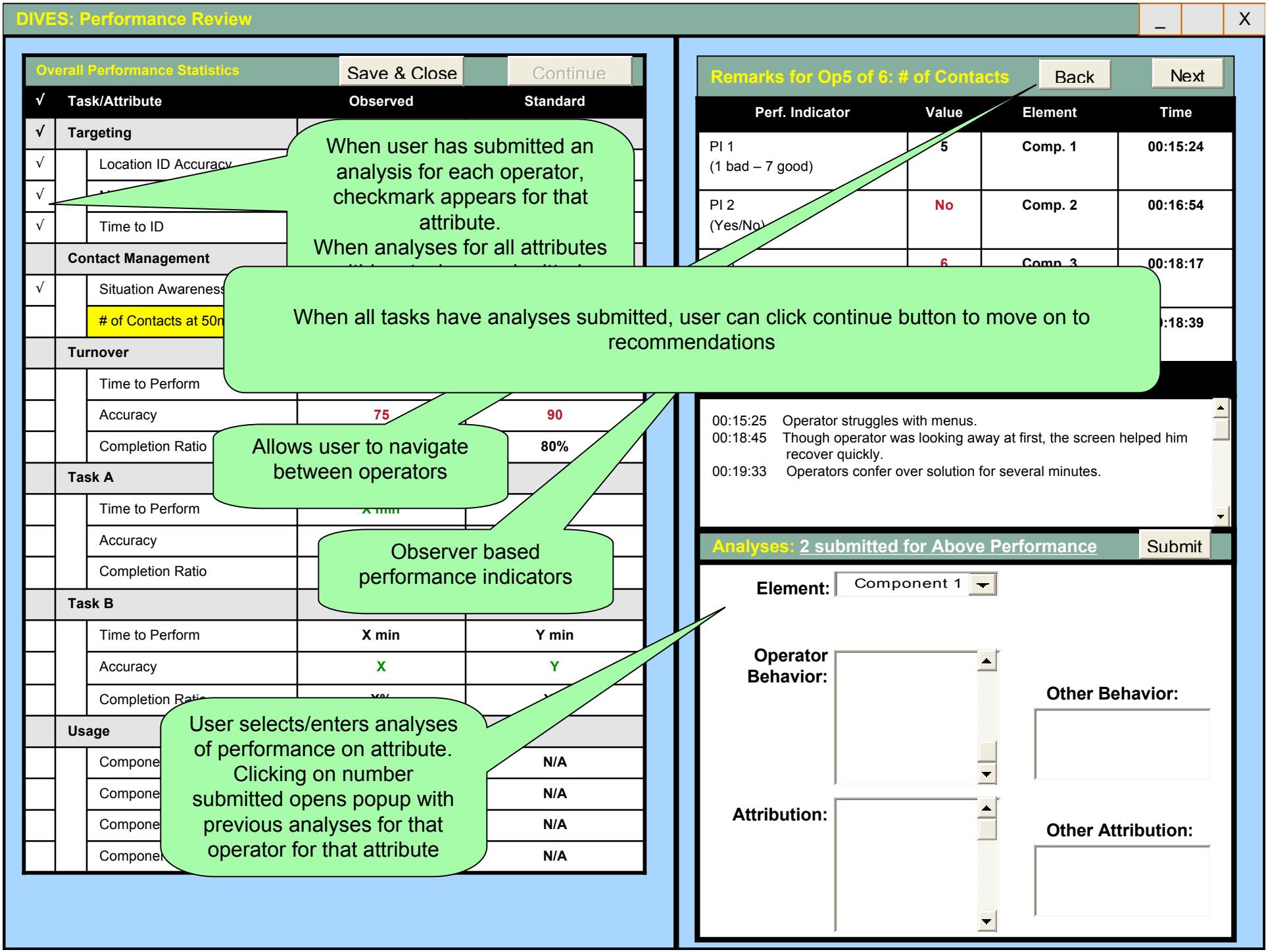
_ X

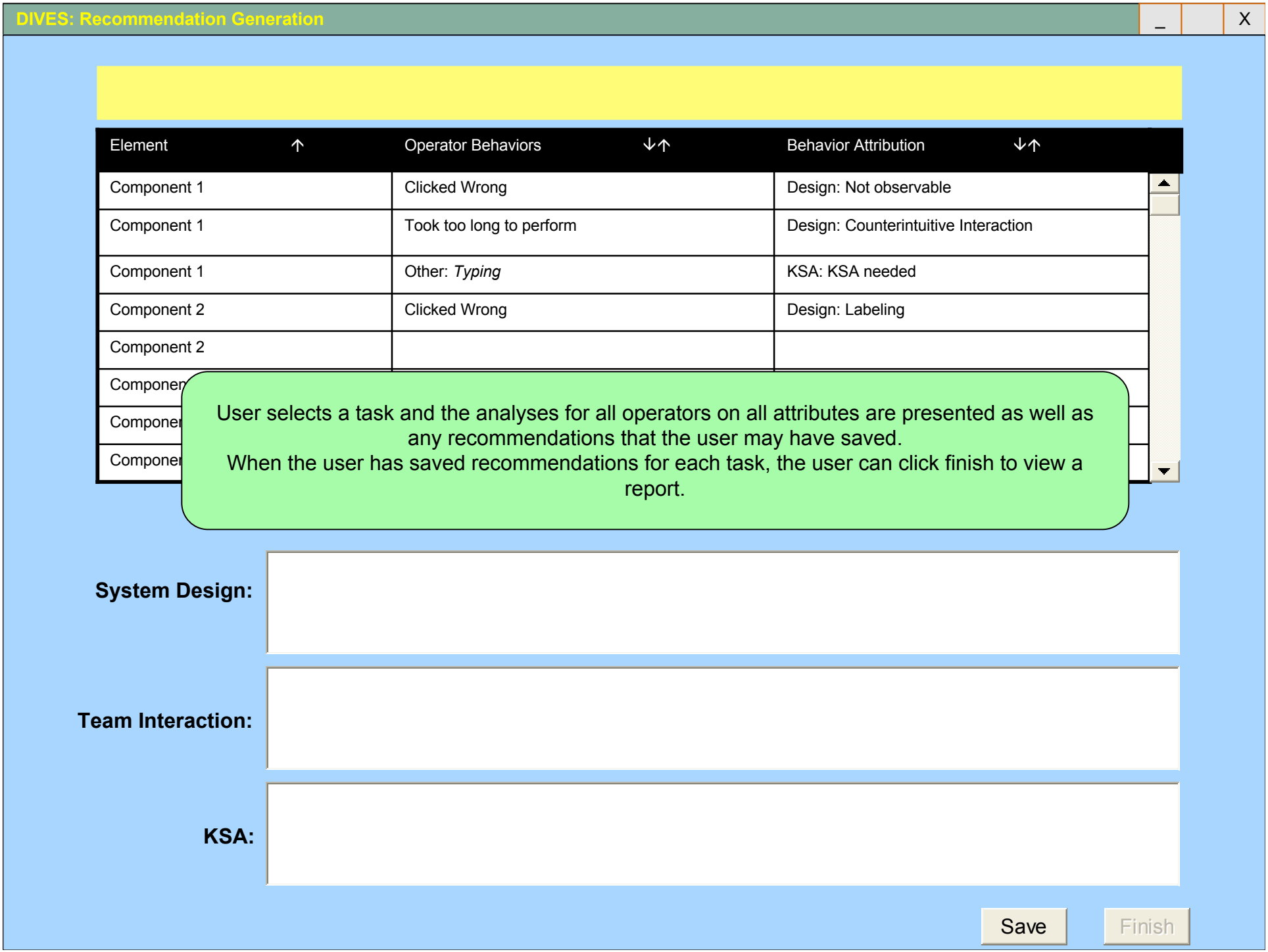
Overall Performance Statistics

Save & Close Continue

√	Task/Attribute	Observed	Standard
	Targeting		
	Location ID Accuracy	75%	75%
	Miss Distance	5m	10m
	Time to ID	7.5 min	5 min
	Contact Management		
	Situation Awareness	80	85
	# of Contacts at 50m	5	20
	Turnover		
	Time to Perform	30 min	15 min
	Accuracy	75	90
	Completion Ratio	80%	80%
	Task A		
	Time to Perform	X min	Y min
	Accuracy	X	Y
	Completion Ratio	X%	Y%
	Task B		
	Time to Perform	X min	Y min
	Accuracy	X	Y
	Completion Ratio	X%	Y%
	Usage		
	Component 1	25%	N/A
	Component 2	20%	N/A
	Component 3	50%	N/A
	Component 4	5%	N/A

User clicks on row to open Observer Remarks & Analyses Windows


DIVES: Performance Review
Overall Performance Statistics
Save & Close
Continue
√ Task/Attribute Observed Standard
Targeting
Location ID Accuracy
Time to ID
Contact Management
Situation Awareness
# of Contacts at 50m
Turnover
Time to Perform
Accuracy 75 90
Completion Ratio 80%
Task A
Time to Perform
Accuracy
Completion Ratio
Task B
Time to Perform X min Y min
Accuracy X Y
Usage
Compone N/A
Compone N/A
Compone N/A
Compone N/A
When user has submitted an analysis for each operator, checkmark appears for that attribute.
When analyses for all attributes
When all tasks have analyses submitted, user can click continue button to move on to recommendations
Allows user to navigate between operators
Observer based performance indicators
User selects/enters analyses of performance on attribute. Clicking on number submitted opens popup with previous analyses for that operator for that attribute
Remarks for Op5 of 6: # of Contacts
Back
Next
Perf. Indicator Value Element Time
PI 1 (1 bad – 7 good) 5 Comp. 1 00:15:24
PI 2 (Yes/No) No Comp. 2 00:16:54
6 Comp. 3 00:18:17
00:18:39
00:15:25 Operator struggles with menus.
00:18:45 Though operator was looking away at first, the screen helped him recover quickly.
00:19:33 Operators confer over solution for several minutes.
Analyses: 2 submitted for Above Performance
Submit
Element: Component 1
Operator Behavior:
Other Behavior:
Attribution:
Other Attribution:


DIVES: Recommendation Generation
_
X
Element
Operator Behaviors
Behavior Attribution
Component 1
Clicked Wrong
Design: Not observable
Component 1
Took too long to perform
Design: Counterintuitive Interaction
Component 1
Other: Typing
KSA: KSA needed
Component 2
Clicked Wrong
Design: Labeling
Component 2
User selects a task and the analyses for all operators on all attributes are presented as well as any recommendations that the user may have saved.
When the user has saved recommendations for each task, the user can click finish to view a report.
System Design:
Team Interaction:
KSA:
Save
Finish

DIVES: Report Overview

Tasks	System Design	Team Interaction	KSA
Targeting	Element: Recommendation: ⋮	Element: Recommendation:	Element: Recommendation:
Contact Management	Element: Recommendation:	Element: Recommendation:	Element: Recommendation:
Turnover	Element: Recommendation:	Element: Recommendation:	Element: Recommendation:
Task A	Element: Recommendation:	Element: Recommendation:	Element: Recommendation:
Task B	Element: Recommendation:	Element: Recommendation:	Element: Recommendation:

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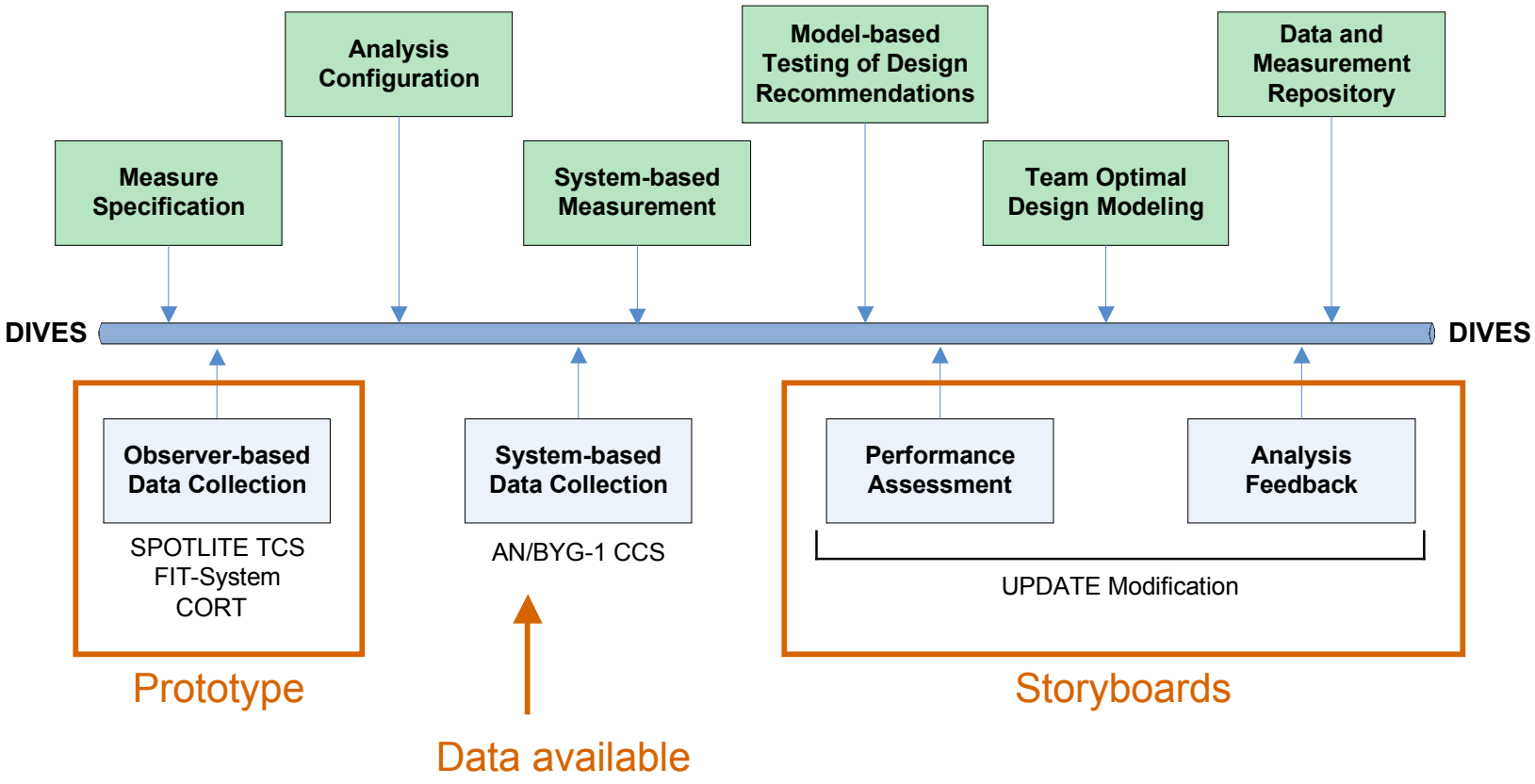
DIVES



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Next Steps

- Complete development of competencies, performance indicators (PIs) and performance measures (PMs) for Fire Control
- Complete mapping of PIs/PMs to design issues
  - Human-systems interactions, operator training, team processes
- Complete SPOTLITE tool for TCS
- Customize UPDATE interfaces and model to accommodate observer-based performance measures and system-based data sources

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Transitions of the Concept

- From…
  - Work we are pursuing in the training domain with AFRL and NAVAIR TSD, and in traditional HCI with AFOSR
- To…
  - NASA Phase I SBIR
    - Building SPOTLITE tool to provide competency- and observer-based performance evaluation of advanced cockpit technologies (e.g., synthetic vision systems)
  - Interest in the integration of SPOTLITE and UPDATE tools at recent demo of UPDATE to HSP-AC

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